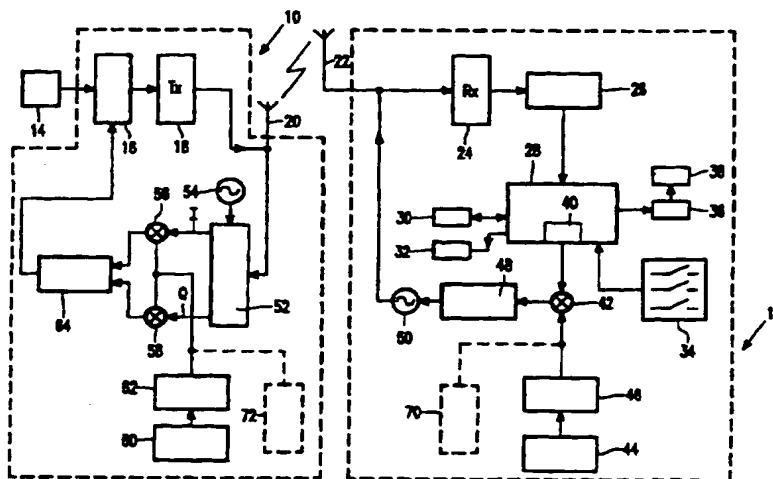


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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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**(54) Title:** COMMUNICATIONS SYSTEM AND TRANSMITTING MEANS THEREFOR**(57) Abstract**

A spread spectrum communications system comprises a transmitter (40-50) and a receiver (52-64). The transmitter includes mixing means (42) having a first input for connection to a data source (40) and a second input for connection to means (44, 46) for providing a dc free encoded spreading sequence. The output from the mixing means (42) is applied to a pulse shaping filter (48), the output of which controls the frequency of a voltage controlled oscillator (50). The signal which is received at the receiver is applied to a frequency down converter (52) which produces quadrature related signals (I, Q) which are applied to first inputs of mixers (56, 58). A dc free encoded spreading sequence is provided by a spreading sequence source (60) and encoder (62) and is applied to second inputs of the mixers (56, 58); the applied encoded spreading sequence corresponds to that applied to the mixing means (42) in the transmitter. The despread outputs from the mixers (56, 58) are applied to a symbol estimator (64) which recovers the received data. Optionally, a plurality of dc free encoded spreading sequences may be stored in a ROM, and by applying an appropriate address signal to the ROM, a predetermined dc free encoded spreading sequence is applied to the filter (48).

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## DESCRIPTION

COMMUNICATIONS SYSTEM AND TRANSMITTING  
MEANS THEREFOR

5

## Technical Field

The present invention relates to a communications system, particularly a low cost spread spectrum communications system, and transmitting means therefor.

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## Background Art

A particular, but not exclusive, application for such a system is in transmitting signals such as acknowledgements and simple responses from a digital pager. As is well known digital pagers have small, low capacity batteries and if it is desired for a pager to transmit a signal then it is normally a low bit rate signal which will enable it to be received over a relatively large area.

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In order to enable several pagers to be able to transmit signals substantially simultaneously, it has been proposed to transmit the signals as spread spectrum signals.

20

Direct sequence spread spectrum (DSSS) systems often use Phase Shift Keying (PSK) as the modulation for the spreading sequence. This has the advantage of simplicity in the modulator. In some applications such as reverse channel communications from pagers it is very desirable that the cost of the modulator and transmitter is as low as possible. It is thus attractive to consider use of a Voltage Control Oscillator (VCO) to generate the transmitted signal. This is quite straightforward in conventional PSK communication links. However, it is difficult to precisely specify the VCO sensitivity (that is voltage to frequency characteristic), which means that the phase shift introduced on the carrier by the chip data signal contains a small additional unknown error component in every transmitted symbol. However a large phase offset can accumulate after only a short time. The magnitude and sign of the phase error

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depends on the chip data sequence in the spreading code, and is not equivalent to a simple frequency offset. This makes demodulation after de-spreading very difficult and can lead to the data being corrupted. This problem arises because the demodulation of a DSSS signal effectively requires  
5 estimation of the phase of the despread signal over a large number of chips. In contrast, demodulation of conventional PSK can be carried out symbol by symbol where small phase errors in the modulation process have a negligible impact.

10 Disclosure of Invention

An object of the present invention is to avoid the occurrence of accumulated phase errors in a DSSS system using binary PSK as the modulation for the spreading sequence.

According to one aspect of the present invention there is provided a  
15 communications system comprising a transmitter and a receiver, the transmitter comprising means for providing a dc free encoded spread spectrum signal, filtering means for filtering the spread spectrum signal and an oscillator coupled to an output of the filter, said oscillator providing the transmitting frequency of the transmitter, and the receiver comprising frequency down conversion means  
20 for providing quadrature related frequency down converted signals, means for providing a dc free encoded spreading sequence, respective mixing means having inputs coupled to received a respective one of the quadrature related frequency down converted signals and the dc free encoded spreading sequence provided by said means, and symbol estimating means having inputs  
25 coupled to outputs of the mixing means.

According to a second aspect of the present invention there is provided a transmitter comprising means for providing a dc free encoded spread spectrum signal, filtering means for filtering the spread spectrum signal and an  
30 oscillator coupled to an output of the filter, said oscillator providing the transmitting frequency of the transmitter.

By using a dc free encoded spreading sequence phase offsets will not

accumulate and as a result the effect of any phase errors occurring in transmission will have negligible impact.

If desired the means for providing a dc free encoded spread spectrum signal comprises mixing means having first and second inputs and an output  
5 coupled to the filtering means, a data source coupled to the first input and means for providing a dc free encoded spreading sequence coupled to the second input.

In an embodiment of the present invention a source of a spreading sequence may be provided independently of a dc free encoding means but in  
10 another embodiment of the invention the dc free encoded spreading sequences are stored in a memory and can be read out and mixed with the data source.

An example of a dc free encoder comprises a Manchester encoder in which every input bit is mapped to two bits of alternating sign, for example "1" becomes 01 and "0" becomes 10. Using Manchester coding the spreading  
15 code is transformed from  $n$  into  $2n$  bits. An important feature of the transformed sequence is that the demodulation at the receiver is now straightforward.

Optionally each transmitter is able to provide a plurality of dc free encoded spreading sequences, each of which is representative of a pre-  
20 determined signal, such as an acknowledgement or a simple answer such as "yes" or "no". Each of the dc free encoded spreading sequences may be stored in a read only memory (ROM) and the transmitter may include means for selecting a particular one of the encoded sequences to be read out and applied to the filtering means.

25 The transmitter and receiver may have means for synchronising the timing of the transmitted spreading sequence. By having such a feature then the starting point in a spreading sequence can be predetermined and in consequence used to act as identifying the transmitter from a group of simultaneously transmitting transmitters which make use of the same spreading  
30 code but commence their transmissions at a different pre-determined point within the spreading sequence.

### Brief Description of Drawings

The present invention will now be described, by way of example, with reference to the accompanying drawings, wherein:

Figure 1 is a phase diagram of binary PSK,

5 Figure 2 illustrates the transformation using Manchester coding,

Figures 3A and 3B respectively illustrate two other examples of dc free encoding extending over four bits,

Figure 4 is a box schematic diagram of a communications system comprising a paging system controller coupled to a base station and a digital pager having a transmitter for transmitting low rate digital signals to the base stations, and

Figure 5 illustrates a variant of the digital pager shown in Figure 4.

In the drawings the same reference numerals have been used to indicate corresponding features.

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### Modes for Carrying-out the Invention

Figure 1 illustrates a phase diagram for binary PSK. As is known if the phase shifts by  $180^\circ$  or  $\pi$  radians then a transition from "1" to "0" or vice versa occurs. If as a result of phase errors the "1" and "0" shift to "1'" and "0'" the modulated signal can still be recovered with a high degree of confidence. However, if phase errors are allowed to accumulate then the "1" signal might be shifted to below the abscissa and the "0" signal shifted to above the abscissa with the consequent result that a "1" is estimated to be a "0" and vice versa. Under normal circumstances when PSK demodulation is carried out on a symbol like symbol basis accumulated errors are unlikely to occur.

25

However, if PSK is used in a DSSS system in which the spreading code is not dc free because it has say more "1"s than "0"s or a sequence has portions which have a large majority of one binary digit rather than the other, then phase errors may accumulate leading to the demodulated signal being so corrupt that it is estimated incorrectly leading to the failure to recover the

30

modulating signal.

In accordance with the present invention the or each spreading sequence is encoded in a dc free manner so that irrespective of the number of binary "1"s and "0"s the signal as received is dc free with the result that there will not be any accumulated phase errors which would lead to an incorrect estimation of the signal. Figure 2 illustrates a well known form of dc free encoding which is Manchester coding in which a positive transition is encoded as 01 and a negative transition as a 10. The effect of using Manchester encoding is that if a spreading sequence has  $n$  bits (or chips) then this will become  $2n$  bits after encoding. Since a radio channel is of finite bandwidth then one effect of encoding the spreading sequence is to reduce the symbol rate by half. There are certain applications such as the transmission of acknowledgements and simple responses in a digital paging system where a low data rate can be tolerated.

Figure 3A and 3B illustrate how dc free encoding may be implemented using four bits per symbol. In the case of Figure 3A the bits have the values 1100 and in the case of Figure 3B the bits have the value 1001. However, when integrated over the four bits any phase errors occurring in the binary "1" bits is balanced by the equal and opposite phase error in the "0" bits. As a general rule the groups of  $n$  bits from the original spreading sequence are mapped to  $m$  bits in a modified sequence, where  $m$  is an even number. Further there should be enough distinct dc free patterns of  $m$  bits to represent all possible patterns of  $n$  bits. In designing the DSSS system one should keep in mind the correlation properties of the resulting codes.

Figure 4 diagrammatically illustrates a paging system. The illustrated system essentially comprises two parts the combination of a paging system controller and base station 10 and a pager or subscriber unit 12. A source of paging signals 14 which may comprise a telephone or a data terminal is coupled to a processor 16 in the base station 10. The processor 16 formats the paging signal into a suitable code word structure, for example that used in the CCIR Radio Paging Code Number 1 (or POCSAG), and at the appropriate

moment forwards these to a transmitter 18 in which they are modulated onto a carrier or a nominal carrier in the case of frequency shift keying (FSK) and relayed to an antenna 20. The antenna 20 is also connected to a spread spectrum receiving section to be described later.

5       The subscriber unit comprises an antenna 22 which is coupled to a receiver 24 which may be of known design. An output of the receiver 24 is coupled to a decoder 26 and the decoded signals are passed to a processor 28. The decoder error checks/corrects the data prior to it being passed to the processor 28. In the processor 28 a check is made that the signals are  
10       addressed to the particular subscriber unit. In the event of the paging signal being addressed to the subscriber unit and comprising a message this is stored in a RAM 30 for subsequent retrieval. Annunciating devices 32 which may comprise an acoustic alert, an LED and/or vibrator is coupled to the processor 28. Manually operable switches or keys 34 are also connected to the  
15       processor 28 in order to control its operations. In order to be able to display various control indicia as well as any messages which are read out from the RAM 30 the processor 28 is coupled to a display driver 36 which in turn is coupled to a LCD display panel 38.

      In the present example the subscriber unit is capable of transmitting  
20       acknowledgements and simple response signals in the form of spread spectrum signals to the base station 10. In order to do this the processor 28 includes a data source 40 which in response to the operation of the key pad 34 is able to select an appropriate response which comprises a low rate (less than a 100Hz) data signal which is applied to one input of a mixer 42. A spreading sequence  
25       or a preselected one of two or more spreading sequences stored in a store 44 is read out and applied to a dc free encoding stage 46. The encoding stage may operate in accordance with Manchester coding. The dc free spreading code at the output of the encoding stage is applied to another input of the mixer 42 which provides a dc free spread spectrum signal as its output. The output  
30       of the mixer 42 is applied to a filter 48, for example a differentiator or high pass filter, which carries out pulse shaping (including differentiation of the input

signal). A voltage controlled oscillator (VCO) 50 is connected to the output of the filter 48. The output signal from the filter 48, which signal comprises a series of sharp pulses or spikes, controls the frequency produced by the VCO 50 to provide a PSK signal which is applied to the antenna 22 for transmission  
5 over the communications link, in this instance to the antenna 20 of the base station 10.

The antenna 20 is connected to a frequency down conversion stage 52 to which a local oscillator 54 is connected. The frequency down conversion stage 52 produces quadrature related outputs I, Q which are applied to  
10 respective mixers 56, 58. A source 60 of spreading sequences which correspond to the sequences stored in the source 44 in the subscriber unit 12, is coupled to a dc free encoder 62, for example a Manchester encoder, the output of which is applied to second inputs of the mixers 56, 58. The I, Q signals are multiplied by the same spreading sequence as used at the  
15 transmitter and the despread outputs are supplied to respective inputs of a symbol estimator 64 which recovers the received data using well known techniques such as integrate and dump.

In the event of the spreading sequence not being known then the I,Q signals are multiplied successively by each of the spreading sequences and the  
20 correct sequence is selected, for example by correlation techniques, and passed to the symbol estimator.

The operation of the transmitter in the subscriber unit 12 is synchronised with the receiver in the base station 10 to ensure that the phasing of the transmitted and received signals is correct to ensure proper demodulation. The  
25 synchronisation of the transmitter and receiver may be effected using timing signals incorporated in the transmitted signal and providing a timing recovery circuit in the receiver which makes use of the timing signals to synchronise the receiver with the transmitted messages as received at the antenna 20.

Several variants of the described embodiment are possible and these  
30 include replacing the source of spreading sequences 44, 60 and the dc free encoders 46, 62 by a single source of dc free encoded spreading sequences

70, 72, as shown in broken lines.

In another variant shown in Figure 5 a read only memory (ROM) 74 stores a plurality of predetermined dc free encoded spreading sequences, each of which itself identifies the response to be transmitted. The processor 28 in response to say the actuation of the keys 34 generates a ROM address signal which causes one of the dc free encoded spreading sequences to be read-out and applied to the filter 48. Thereafter the circuit is as described with reference to Figure 4.

From reading the present disclosure other modifications will be apparent to persons skilled in the art. Such modifications may involve other features which are already known in the design, manufacture and use of communication systems and component parts thereof and which may be used instead of or in addition to features already described herein. Although claims have been formulated in this application to particular combinations of features, it should be understood that the scope of the disclosure of the present application also includes any novel feature or any novel combination of features disclosed herein either explicitly or implicitly or any generalisation thereof, whether or not it relates to the same invention as presently claimed in any claim and whether or not it mitigates any or all of the same technical problems as does the present invention. The applicants hereby give notice that new claims may be formulated to such features and/or combinations of such features during the prosecution of the present application or of any further application derived therefrom.

#### Industrial Applicability

Acknowledgement - back pagers and paging systems.

## CLAIMS

1. A communications system comprising a transmitter and a receiver, the transmitter comprising means for providing a dc free encoded spread spectrum  
5 signal, filtering means for filtering the spread spectrum signal, and an oscillator coupled to an output of the filter, said oscillator providing the transmitting frequency of the transmitter, and the receiver comprising frequency down conversion means for providing quadrature related frequency down converted signals, means for providing a dc free encoded spreading sequence, respective  
10 mixing means having inputs coupled to received a respective one of the quadrature related frequency down converted signals and the dc free encoded spreading sequence provided by said means, and symbol estimating means having inputs coupled to outputs of the mixing means.
- 15 2. A system as claimed in claim 1, characterised in that the means for providing a dc free encoded spread spectrum signal comprises mixing means having first and second inputs and an output coupled to the filtering means, a data source coupled to the first input and means for providing a dc free encoded spreading sequence coupled to the second input.
- 20 3. A communications system as claimed in claim 2, characterised in that the means for providing the dc free encoded spreading sequence comprises means for providing a spreading sequence and means for providing dc free encoding coupled to the output of the means for providing a spreading  
25 sequence.
4. A communications system as claimed in claim 3, characterised in that the means for proving dc free encoding comprises Manchester encoding means.
- 30 5. A communications system as claimed in claim 1, characterised in that

the means for providing a dc free encoded spreading sequence comprises storage means for storing a plurality of said dc free encoded spreading sequences, each sequence being representative of a predetermined signal, in that the transmitter has means for selecting the sequence to be transmitted and  
5 in that the receiver has means for determining the predetermined signal from the spreading sequence transmitted.

6. A communications system as claimed in any one of claims 1 to 5, characterised in that the transmitter and receiver have means for synchronising  
10 the timing of the transmitted spreading sequence.

7. A communications system as claimed in claim 6, characterised in that the transmitter has means for predetermining a starting point in a spreading sequence, said starting point being used as an identifier of the transmitter.  
15

8. A transmitter comprising means for providing a dc free encoded spread spectrum signal, filtering means for filtering the spread spectrum signal and an oscillator coupled to an output of the filter, said oscillator providing the transmitting frequency of the transmitter.  
20

9. A transmitter as claimed in claim 8, characterised in that the means for providing a dc free encoded spread spectrum signal comprises mixing means having first and second inputs and an output coupled to the filtering means, a data source coupled to the first input and means for providing a dc free  
25 encoded spreading sequence coupled to the second input.

10. A transmitter as claimed in claim 8, characterised in that the means for providing a dc free encoded spreading sequence comprises storage means for storing a plurality of said dc free encoded spreading sequences, each  
30 sequence being representative of a predetermined signal, in that the transmitter has means for selecting the sequence to be transmitted and in that the receiver

has means for determining the predetermined signal from the spreading sequence transmitted.

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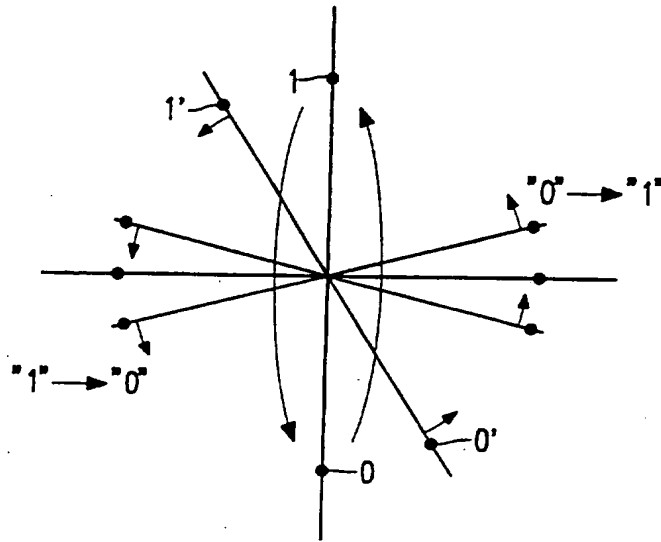


FIG. 1

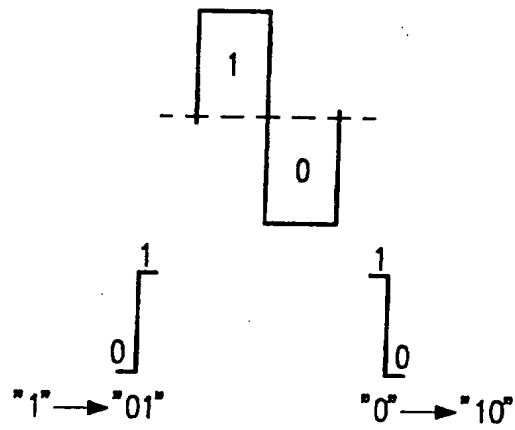


FIG. 2

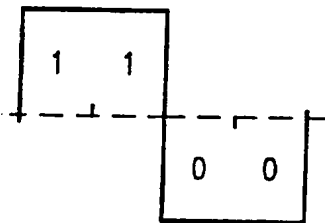


FIG. 3A

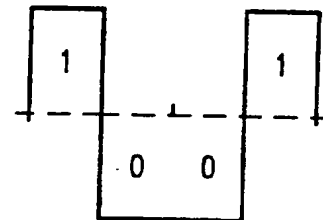
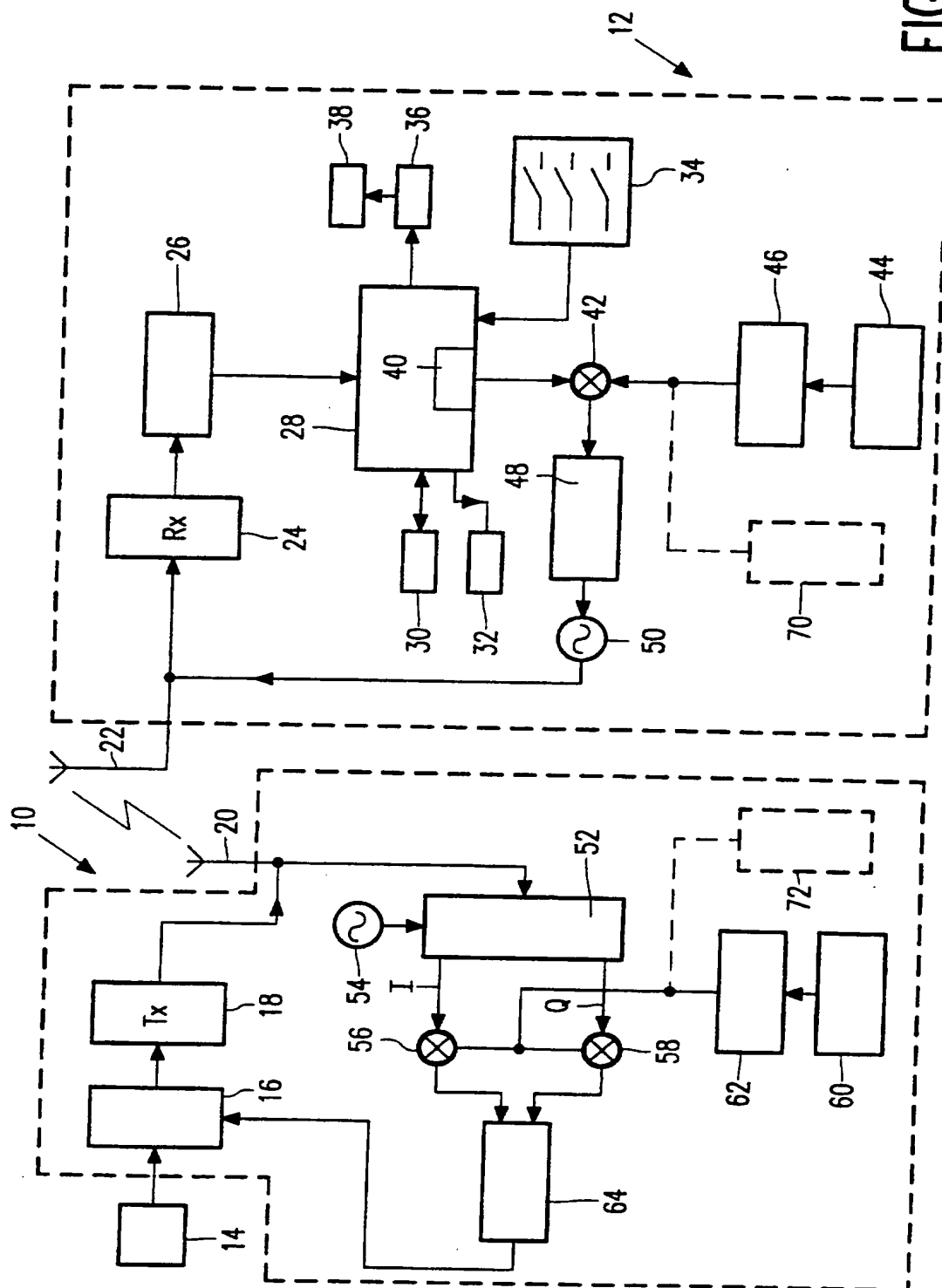


FIG. 3B

**FIG. 4**



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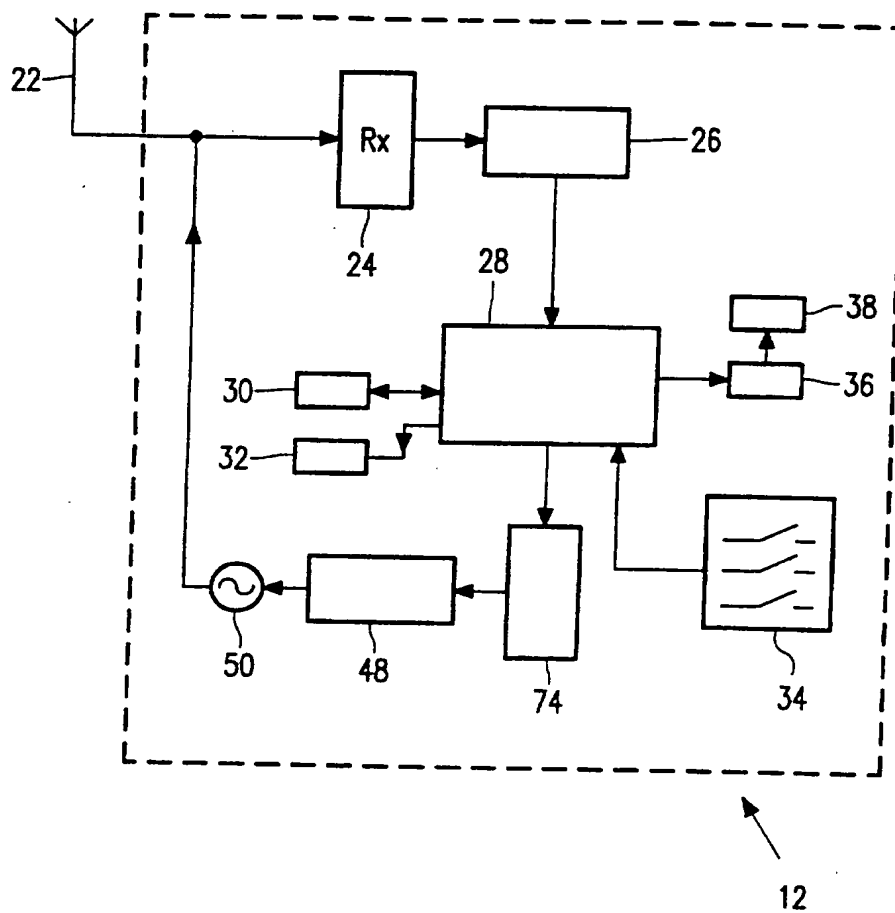


FIG. 5